AGRIGUM INTERNATIONAL

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Section 1: Overview

GUM ARABIC'S (GUM ACACIA'S) JOURNEY FROM TREE TO END USER

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1 INTRODUCTION

Gum acacia, also known as gum arabic, is exuded from Acacia trees - mainly from *Acacia senegal* and *Acacia seyal*. The main gum acacia producing countries are Sudan, Nigeria, Chad and Senegal. Sudan is considered to be the world's largest producer of gum acacia. Gum acacia is the oldest and best known of all the polysaccharide plant exudates. It was used by the Ancient Egyptians in their paintings as an adhesive for mineral pigments and as an adhering agent to make flaxen wrappings for embalming mummies.[1] It has been reported that the gum acquired the name "gum arabic" after its place of origin or port of export to Europe.[2] A different explanation has been given by a Sudanese researcher who concludes that the name originates from a Sudanese tribe called Beja who live near the Red Sea and ports of export. In the Beja language, arabic means "transparent" and gum arabic refers to "excellent quality of gum that is transparent and free from bark".

Gum acacia (INS No. 414) is defined by FAO/WHO Joint Expert Committee on Food Additives (JECFA) in FNP 52 Add 7 (1999) as: "Gum arabic is a dried exudate obtained from the stems and branches of *Acacia senegal (L.) Willdenow* or *Acacia seyal (fam. Leguminosae)"*. Acacia gum is defined by the European Pharmacopoeia 6.8 as: "Air-hardened, gummy exudates flowing naturally from or obtained by incision of the trunk and branches of *Acacia senegal L. Willdenow*, other species of Acacia of African origin and *Acacia seyal Del.*". United States Pharmacopoeia Official Monograph for NF26 (USP 31) defines gum acacia as: "Acacia is the dried gummy exudates from the stems and branches of *Acacia senegal (Linné) Willdenow* or of other related African species of Acacia *(Fam. Leguminosae)*". The Japanese Official monograph for part II / Powdered Acacia (JP XIV) defines gum acacia as: "Acacia is the secretions obtained from the stems and branches of *Acacia senegal Willdenow* or other species of the same genus (*Leguminosae*)".

Gum acacia is a highly heterogeneous complex polysaccharide consisting of galactose, arabinose, rhamnose, glucuronic acid and 4-*O*-methylglucuronic acid.[3-8] The carbohydrate composition can vary, depending on the location, the age of the tree and site of tapping, and from season to season.[7] Also, gum acacia consists of a small amount of protein (~0.8% with *A. seyal* & ~2.0% with *A. senegal* gums), which forms an integral part of the gum structure. Gum acacia has been fractionated by hydrophobic chromatography into three

principle fractions, which are Arabinogalactan (AG), Arabinogalactan-protein (AGP) and glycoprotein (GP).[7,9-12]

The physicochemical and nutritional data for *A. senegal* and *A. seyal* gums are shown in Table 1. The data shows that *A. senegal* gum has a higher potassium content and emulsion capacity compared to *A. seyal* gum, while *A. seyal* shows a slightly higher calcium content and slightly lower viscosity and ash content. Specific optical rotation is one of the most important quality control tools used by the gum acacia suppliers and manufacturers to differentiate between both gums.

Table 1 *Physico-chemical characteristics and nutritional data for A. senegal and A. seyal gums (typical values)*

Parameter	***A. senegal* gum**	***A. seyal* gum**
Appearance	Amber, transparent, hard nodules	Red/brown fragile fragments
Nutritional value (Kcal/g)	1.7	1.7
Total fat (%)	0	0
Complex carbohydrates (%)	95	95
Soluble dietary fibre (%)	>85	>85
Protein (%)	~2	~0.8
Tannins (%)[13]	0	0.11
Potassium (ppm)	8,500	2,000
Calcium (ppm)	9,000	11,000
Magnesium (ppm)	1,400	1,200
Viscosity (25% w/v soln, cps)	100	80
Emulsion capacity	High	Low
Specific optical rotation (°)	-30	+50
pH	4.5	4.4
Ash (%)	3.2	2.7

2 TAPPING

The weather (temperature) has a considerable influence as to when the gum season starts. If the weather is hot enough directly after autumn (October / November), the leaves will start falling, which is a signal to start tapping the *A. senegal* trees. The traditional tapping tool was an axe, but modern practise in the Sudan is to use a sharp spear (Sonke) to pierce through an upper branch (or stem) just beneath the bark (not to damage the cambial zone). The spear is then moved up and down along the length of the branch to remove part of the bark and expose an area of the cambial layer about 30 cm long and 5 cm wide. Expert tappers always ensure that no peeled bark is left on the tree, which could stick to the gum nodules. *A. seyal* trees normally exude the gum naturally although recently farmers have started to tap these trees also.

3 GUMMOSIS

The gum oozes from the stems and branches of the tree within a zone between the inner bark and the cambial zone,[16] when the tree is subjected to stress conditions such as drought (*A. seyal*) and wounding.[5] The trees must be 5 years or older for gum production to occur, suggesting therefore that gum production is in direct competition with tree growth. Gum exudes in nodule form up to 60 mm in diameter, which then dries in the sun. *A. senegal* forms hard, glass like lumps which are transparent to amber in colour. *A. seyal* forms fragile fragments which are amber to brown in colour. A number of hypotheses have been suggested for the biosynthesis of the gum, which is referred to as "gummosis". It was proposed that gummosis is a pathological process resulting from a bacterial or fungal infection of the injured tree,[17] and efforts were made to isolate the bacteria and moulds that may be involved in the formation of the gum.[18] Others believe that gummosis is part of the normal plant metabolism or directly related to starch metabolism and the gum acacia is produced in response to physiological disturbances induced by stress.[16,19,20]

4 COLLECTION

The exudate gum hardens in the sun to form nodules, which are manually collected after 4-6 weeks from tapping, followed by 3-5 collections every 2 weeks, depending on the weather conditions and the health of the tree.[21]

5 DRYING

Drying the gum after collection is a very important process to prevent fermentation and forming of agglomerated gum nodules (jammed gum). The gum is spread evenly to dry for a few days. It is recommended to avoid direct sun drying as the gum nodules break into small fragments and siftings. Drying the gum under 45% shade will help in drying the gum nodules without compromising the hand picked selected (HPS) and lump quality gums.

6 MANUAL CLEANING

The crude gum is pre-cleaned manually from sand and bark using sieves and trays. This is traditionally done by women, who manually sort the gum according to the size of the lumps and remove foreign matter.[22]

7 PROCESSING

The processing of gum acacia can be split into three categories:

- Mechanical processing
- Spray-Drying
- Agglomeration

7.1 Mechanical processing

Figure 1 shows the mechanical processing, which involves cleaning, grading and generating a range of different particle sizes from the original lump gum. The mechanical processing also includes the Kibbling stage - a grinding process - which breaks up the gum nodules into various specific particle sizes of approximately 0.5 mm to 6.0 mm. The Kibbling process increases the surface area of the gum particles and this allows the gum to dissolve faster in water compared with the lump gum. Mechanical powder can also be produced by further milling the kibbled gum, using mostly pin mills. Although the produced kibbled and milled gums are subjected to various mechanical cleaning steps, they still contain some amount of bark and foreign materials.

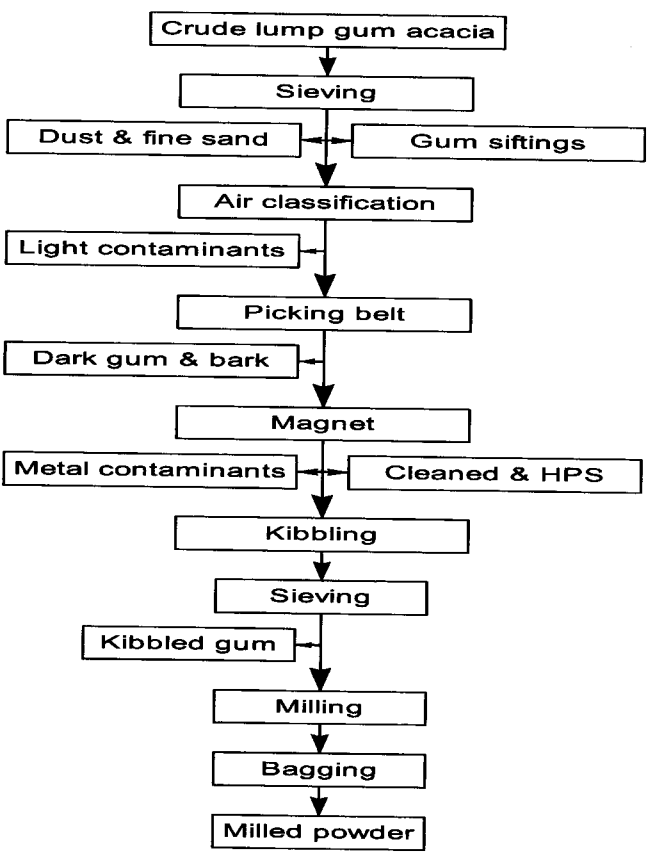

Figure 1 *Gum acacia mechanical processing flow chart*

7.2 Spray-drying

The spray drying process shown in Figure 2 starts by dissolving the Kibbled gum in water followed by several filtration stages to remove the impurities. The gum solution is then decanted, centrifuged, and then passed through ultra fine filters to remove the fine insoluble material. In order to free the gum from any contaminated pathogenic micro-organisms and to reduce the total bacterial yeasts and moulds count, the gum solution is subjected to a pasteurisation process. The pasteurised gum solution is sprayed into fine droplets by atomisation or jets in a stream of hot air, which rapidly evaporates the water. Cyclones are used to separate dry gum powder from dry air.[23]

The spray-drying process allows gum to be efficiently purified to give a consistent product. This can then be used directly in applications without recourse to further cleaning, chemical, physical, or microbiological procedures. The vast majority of the food and pharmaceutical industries now specify spray-dried gum acacia because of its benefits in all types of applications.

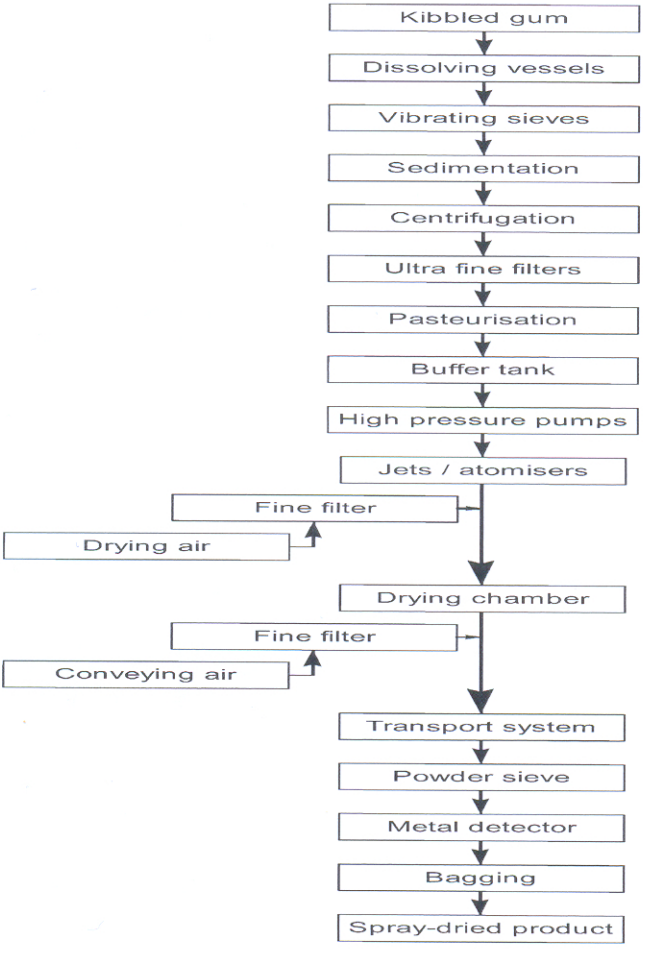

Figure 2 *Gum acacia spray-drying process flow chart*

7.3 Agglomeration

The agglomeration process summarised in Figure 3 involves suspending the spray dried gum acacia powder on a bed of air, then spraying water or gum solution onto this to cause particles to stick together. The produced agglomerated powder is then dried and sieved to produce a product with a consistent and narrow range of particle size. The advantage of the agglomeration process is that it produces environmentally friendly, dust-free gum acacia powder products and improves significantly the dispersability, sinkability, solubility and dissolving characteristics of the spray-dried gums. Customers using the agglomerated gum powder do not need very powerful mixers to dissolve the gum.

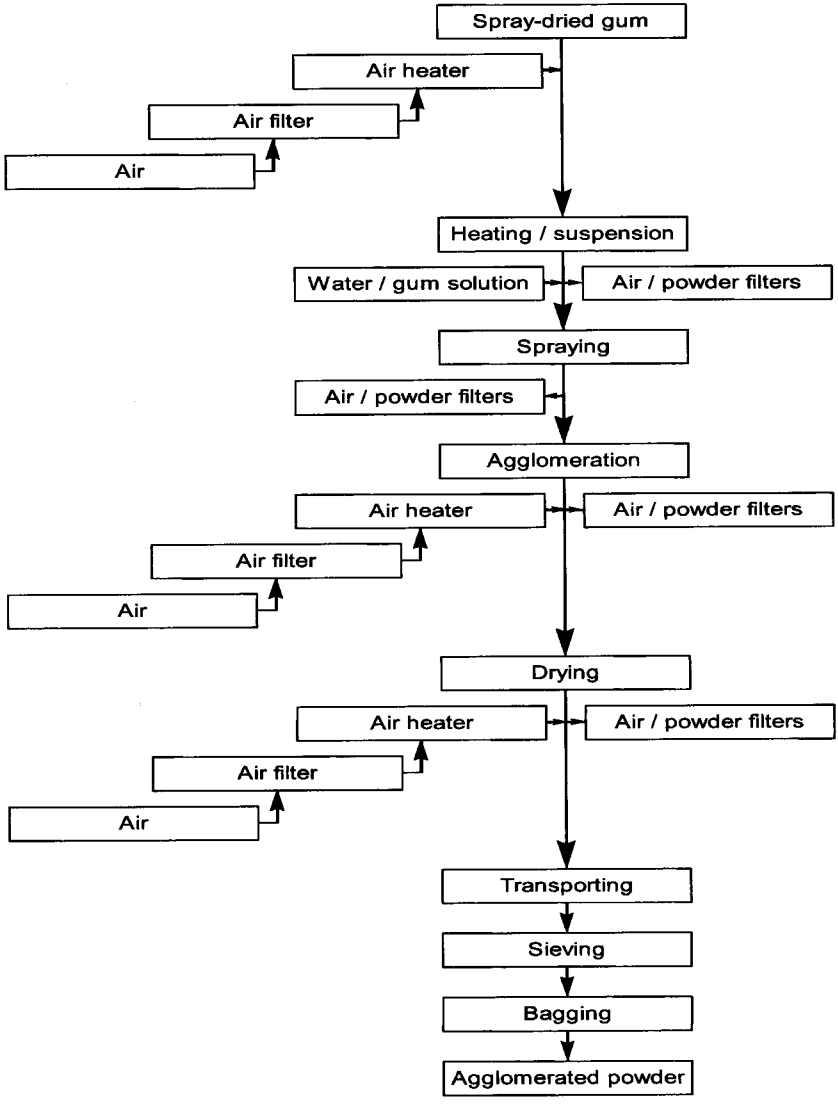

Figure 3 *Gum acacia agglomeration process flow chart*

8 FUNCTIONAL PROPERTIES

Gum acacia has many properties that make it unique.

8.1 Solubility

Gum acacia is unique among natural hydrocolloids in that it is highly soluble in hot and cold water. Most gums cannot be dissolved in water at concentrations higher than 5% due to their high viscosity, but gum acacia can yield solutions up to 50% concentration. The ability of gum acacia to form these concentrated solutions without an excessive increase in viscosity is due to the high degree of branching within the gum structure and therefore small hydrodynamic volume.[24,25]

Gum acacia is insoluble in oils and in most organic solvents and is soluble in aqueous ethanol up to a limit of about 60% ethanol.

8.2 Emulsifying properties

Gum acacia from *A. senegal* is a very effective emulsifying and stabilising agent and has found widespread use in the preparation of varied oil-in-water beverage emulsions. It is not less than the gold standard of emulsifiers used in beverages.[26]

The gum contains a protein deficient, low molecular weight arabinogalactan (AG), a protein rich glycoprotein (GP) and a high molecular weight arabinogalactan-protein complex (AGP).[7,11] The AGP complex is preferentially adsorbed onto the oil droplets and it is this which stabilises the emulsion. The large hydrophilic polysaccharide blocks of the AG fraction extend into the aqueous phase and prevent coalescence due to the steric repulsion between droplets.[10,27]

Processing factors such as pasteurisation and demineralisation of the gum promote emulsion stability, most likely by promoting protein unfolding and eliminating the screening effect, respectively.[28]

8.3 Viscosity

Most gums form highly viscous solutions at low concentrations (<5%). However, at such relatively low concentrations, gum acacia yields solutions that are essentially Newtonian in behaviour and have very low viscosities compared to other polysaccharides of similar molecular mass.[29]

Table 2 and Table 3 show study results of the effect of concentration and temperature on the viscosity of Agri-Spray Acacia RE (*A. senegal* gum) and Agri-Spray Acacia MGH (*A. seyal* gum) products. The viscosity results of the products produced from both *A. senegal* and *A. seyal* gums show an increase in viscosity following an increase in concentration, and a decrease in viscosity when the gum solution is subjected to an increase in temperature. *A. senegal* gum shows slightly higher viscosity results than *A. seyal* gum.

At concentrations above 40%, both *A. senegal* and *A. seyal* gums produced solutions with a considerably higher viscosity. These findings agreed with previous studies that showed hydrated gum acacia molecules above 30% concentration effectively overlap, and steric interactions result in a much higher solution viscosity.[29]

Table 2 *Viscosity of Agri-Spray Acacia RE (A. senegal gum) at different concentrations & temperatures*

Gum conc. (%)	Viscosity (cps)					
	10°C	25°C	40°C	50°C	60°C	70°C
1	3	2	2	2	1	1
5	5	4	3	3	3	2
10	12	10	8	7	6	5
15	27	20	14	13	11	10
20	53	44	30	26	21	18
25	140	95	61	47	41	38
30	309	196	119	98	80	70
35	626	430	252	196	157	130
40	1,014	989	554	390	312	275
45	>10, 000	4,140	1,355	930	770	666

Table 3 *Viscosity of Agri-Spray Acacia MGH (A. seyal gum) at different concentrations & temperatures*

Gum conc. (%)	Viscosity (cps)					
	10°C	25°C	40°C	50°C	60°C	70°C
1	3	2	2	1	1	1
5	5	4	3	3	3	2
10	10	8	6	5	5	4
15	23	20	15	13	11	9
20	48	39	27	22	21	16
25	99	83	53	45	36	31
30	225	210	125	101	78	59
35	579	414	245	176	131	103
40	1,540	946	525	457	267	200
45	>10,000	2,390	1,385	695	492	474

8.4 Effect of pH and electrolytes

The viscosity of gum acacia solutions decreases with the addition of electrolytes and this is explained by a reduction in the effective volume due to the suppression of the electrostatic charge. Solutions of gum acacia are slightly acidic (typical pH is 4.5) and at this pH, the gum is at its maximum viscosity. Gum acacia is stable over a wide range of pH from 3.0 to 9.0.[30]

8.5 Compatibility

Gum acacia has a broad range of compatibilities and is compatible with most gums, starches, carbohydrates and proteins. It is incompatible with sodium alginate and gelatine. With gelatine, gum acacia forms a well-known coacervate utilised in the preparation of encapsulated oils. A synergistic viscosity decrease was reported with a mixture of gum tragacanth and gum acacia, which reached minimum viscosity at 80% gum tragacanth and 20% gum acacia.[21]

8.6 Effect of heat

Prolonged heating causes the thermal destruction of gum acacia. It results in the denaturation and precipitation of the proteins from the high molecular weight AGP and GP complexes and this causes a reduction in the emulsification capacity and solution viscosity.[31]

8.7 Sensory properties

A. senegal gum is generally odourless, colourless and tasteless,[21] while *A. seyal* gum is slightly dark in colour.

8.8 Nutraceutical properties

Gum acacia is a complex, non-starch polysaccharide, indigestible to both humans and animals but fermented in the colon to produce short-chain fatty acids, leading to a wide range of potential health benefits.[32] It thus meets dietary fibre definitions that are adopted by the European Union and Codex Alimentarius. The typical fibre content of gum acacia is in excess of 85% (AOAC method). Due to the complex, highly branched molecular structure of gum acacia, its fermentation is very slow and this reduces the bloating side effect.

Gum acacia is a prebiotic, soluble fibre that feeds and stimulates the growth and activity of the beneficial bacteria (probiotic) in the colon.[33-36]. Probiotic bacteria strengthen the immune system to combat allergies, stress, exposure to toxic substances and other diseases. It has been reported that studies *in vivo* and *in vitro* with gum acacia show compatibility in the diet of patients suffering with diabetes mellitus, and a reduction in systolic blood pressure, which may translate into an improved cardiovascular outcome and a reduction in the progression of renal disease.[32]

A calorific value of 1.7 Kcal/g for gum acacia has been confirmed by the Food and Drug Administration (FDA) and can be used for the calculation of gum acacia energy contribution.

9 APPLICATIONS

Gum acacia enjoys a remarkable diversity of applications and this is mainly due to its desirable physicochemical properties and functions as reported earlier. The functions of gum acacia include emulsifier, formulation aid, stabiliser, thickener, surface finishing agent, processing aid, firming agent, texturiser, adhesive, plasticiser, soluble fibre and prebiotic source, and many others.

9.1 Confectionery

Gum acacia has been widely used in the confectionery industry for many centuries. This is due to its ability to prevent sugar crystallisation, modify texture, emulsify and keep fatty components evenly distributed. It can also act as a boundary film in glazing systems.[37,38]

9.1.1 High Sugar Confectionery (Pastilles, Candies, Gum Drops): In pastilles and candies, gum acacia is used in concentrations up to 45% to inhibit sugar crystallisation and as a binder. The traditional wine gums and gum drops (or fruit gums) were originally prepared exclusively with gum acacia,[39] as a higher clarity could be achieved compared to other hydrocolloids, and the resistance to melt-away, shape retention, bland taste and odour, pliable texture, and low adhesion when chewed, are all major benefits of this gum.[21] Other properties of providing slow, controlled flavour release, protecting flavours from oxidation and controlling sugar crystallisation are also valuable. Jelly candies, which are similar to gum drops, are made with gum acacia but can be produced with agar, starch, pectin and gelatine.[40] Depending on the concentration of gum acacia, the sugar types and proportions, and the residual moisture in the confectionery, textures ranging from soft lozenges and pastilles to hard gums can be produced.[41]

9.1.2 Reduced Sugar and No-Sugar Confectionery: Gum acacia performs very well in replacing the bulk and texture of sugars in combination with artificial sweeteners e.g. sorbitol, as well as providing binding and fibre in low calorie confections. Reduced calorie nougat candies have been made by incorporating up to 27% each of gum acacia and microcrystalline cellulose (MCC) in the standard nougat composition.[42] Calorie reductions of over 50% have been achieved in toffee by using higher levels of gum acacia with MCC.[43]

9.1.3 Compressed Sugar Confectionery (Tablets, Lozenges, Extruded Paste): Gum acacia is used as the binding agent and paste base for forming the stiff dough that is rolled in sheets and stamped into lozenges.[44]

9.1.4 Caramels and Toffees: Gum acacia keeps the fat uniformly distributed throughout the caramel and toffee confection, and that prevents the fat from rising to the surface where it causes problems as an easily oxidised, greasy film.[44]

9.1.5 Coated Products (Dragees, Chewing Gum, Chocolate Centres, Nut Centres, Coated Almonds, Chocolate Coated Peanuts and Raisins): In making sugar-coated confections such as sugared almonds, a panning process is employed where gum acacia solutions are used to coat the nut before the final sugar coating is applied.[44] With chocolate-coated products the gum solution is applied as the final coating. In all such applications, gum acacia functions as a film forming or a glazing/coating agent.

9.1.6 Chewing Gum: Gum acacia performs a variety of roles associated with chewing gum manufacture, including flavour carrier, control of flavour release and texture improver. Gum acacia is also used to glaze and coat finished chewing gum pieces to seal and protect the flavour, improve resistance to humidity and give a pleasing, shiny appearance to the product.[45]

9.1.7 Snacks (Dry Roasted Peanuts, Spicy Nuts): A concentration of up to 25% gum acacia solution is used in this application as an adhesive coating to apply seasoning to such products as dry roasted peanuts.

9.1.8 Chewy Candies: Gum acacia is used in the manufacture of chewy sweets at low levels (1-2%) as gelatine is the main texturising agent. Gum acacia is used to give additional adhesion, to reduce elasticity and to give extra fine sugar crystallisation with a smooth texture.[21] However, with the concerns over BSE in cattle and the use of their by-products, gelatine is gradually being completely replaced with gum acacia in combination with other hydrocolloids.

9.2 Bakery products

In the baking industry, gum acacia is used for its comparatively low water-absorption properties. In addition, it has favourable adhesive properties for use in glazes and toppings and imparts smoothness when used as an emulsion stabiliser.[43] Gum acacia imparts stability in bun glaze in conjunction with free flowing and adhesive characteristics. The glaze, applied while still warm, adheres firmly when the bun cools. It also imparts flexibility and pliability to the glaze.[43]

Glossy coatings and the effective binding and sealing of baked goods and cereals often use gum acacia. Stock solutions of gum acacia (30-50%) are prepared for spraying or brushing the coating onto the biscuit or pastry before baking. When the gum solution evaporates, an attractive glossy coating forms. Furthermore, gum acacia binds water to help retain humidity, and control moulding and rolling properties in high sugar icings. These glazes are applied warm to the baked products and the gum acacia performs adhesion between surfaces.[21]

9.3 Flavours and beverages

Gum acacia has been used extensively for many years in the flavour and beverage industry due to its unique emulsifying, stabilising, encapsulating, low viscosity and acid stability properties.

9.3.1 Liquid Flavour Emulsions: Gum acacia is extensively used to prepare and stabilise essential oil emulsions (orange, lemon, lime, cherry and cola), which are supplied to the soft drinks industry. A high concentration of gum acacia is required to stabilise a beverage emulsion, as the oil droplet surface should be fully covered to prevent flocculation and coalescence. In general, as much as 20% gum acacia may be needed to stabilise a 12% beverage emulsion.[26,30]

9.3.2 Spray Dried Flavour Encapsulation: Gum acacia is universally known as an excellent encapsulating material for flavours. This is due to its emulsification properties, low viscosity, bland flavour and for its protective action against flavour oxidation during processing and storage.[21] Several dry-food products including dessert, pudding mixes, soups and beverages powders, contain encapsulated flavours for flavour stability and a longer shelf life. A pre-spray drying liquid emulsion is first formed, with a formulation that might contain 7% oil based flavour and 28% gum acacia.[46]

9.3.3 Flavoured Beverages with Added Cloudiness and Pulps: As well as the encapsulation of flavours and juices, gum acacia can act as a clouding agent in dry beverage mixes. A spray dried emulsion of gum acacia and vegetable oil gives a stable, encapsulated, free flowing powder, that when dispersed in water, gives cloudiness or turbidity imitating the effect of added pulps of citrus and other fruit juices.[47]

9.3.4 Nutritional Drinks: Gum acacia is used increasingly as a source of soluble fibre in low calorie and dietetic beverages.[48] The FDA Daily Recommended Value (DRV) for fibre is 25 grams, with formulation requirements based on serving sizes. Products labelled "Good Source" or "Fibre Fortified" must contain 2.5 g (10% of DRV) per serving, while products labelled "High Fibre" must contain 5 g (20% of DRV) per serving.

9.3.5 Wine Fining and Stabilisation: In wine fining very low levels of gum acacia react with proteins to form flocs and sediments, which can be removed by decanting or filtration to clarify the wine and stabilise its colour. Typically *A. senegal* Kibbled gum or *A. seyal* Talha gum are used for wine clarification, but these must be filtered and heat-treated prior to addition to the wine. More convenient alternatives are spray dried gum acacia products.

9.3.6 Beer Brewing: The charged uronic acid residues on gum acacia interact with the proteins in beers and lagers to stabilise the foam and assist lacing - the adhesion of the foam to the glass during drinking.[49] Low levels of around 250 ppm of high quality gum acacia are required to avoid cloudiness in the drink.[21] The mass cask-beer market uses carrageenan and isinglass, or alginates, for fining. A 0.1% solution of gum acacia is used as an alternative to carrageenan in speciality beers.

9.4 Other food applications

9.4.1 Food Colours: Gum acacia is used as a base for the preparation of spray dried colour oleoresins such as annatto, paprika and turmeric. It can also be used to prepare and stabilise liquid colour emulsions.

9.4.2 Nutritional Foods: Gum acacia is designed as a convenient means of adding soluble fibre to high fibre/low fat food products ranging from yoghurts to cakes. Gum acacia delivers in excess of 85% total dietary fibre. Hence, the use of gum acacia affords all the benefits associated with soluble fibre without the adverse effects to the textural properties of the food.

9.4.3 Protective Coatings: Oil-soluble vitamins such as vitamin A are stabilised by spray drying them in an emulsion containing antioxidant, fat, lactose and gum acacia to give an encapsulated powder retaining 85% of its vitamin activity after 12 months storage at room temperature. A coating of gum acacia will help protect unstable oils and flavours from the development of rancidity and off-tastes.[43]

9.5 Pharmaceuticals

Gum acacia has been used successfully in a variety of pharmaceutical products because of its many functional properties such as a binder, adhesive and glaze for pharmaceutical tablets.[50] In demulcent syrups, it is used for its soothing and protective action, as a suspending agent and as an emulsifying agent. Gum acacia is also used as one of the main ingredients in medicated cough drops and lozenges.

9.5.1 Cosmetics: In cosmetics, gum acacia has a variety of roles as a result of its excellent functions such as a stabiliser. It also imparts spreading properties, gives a protecting coating and a smooth feel. It is used as a binding agent for cake material and an adhesive in facial masks. Gum acacia is used in the formulation of mascara, facial moisturiser, other moisturisers, anti-aging creams, body wash/cleaner, liquid hand soaps, hair spray, eyeliner, lipsticks and others.[51]

9.6 Printing and paints

9.6.1 Lithography: In lithography, gum acacia is used as a sensitiser for lithographic plates,[22] as it confers good viscosity control and generates uniform layers of adsorbed film, producing a uniform coverage of material on the plates used. Gum acacia solutions are also used to generate a protective film for storage of the printing plate, and to emulsify solvents in the preparation of cleaning solutions.

9.6.2 Inks: Gum acacia has been used as an emulsifier or suspending agent in a variety of different types of inks because of its protective colloid properties.

9.6.3 Water Colours: Gum acacia is traditionally used in water colours as a binder because it is highly soluble in water, low in viscosity and when it dries, forms a thin layer that binds pigments to the paper surface. Gum acacia increases the water colour brilliancy, gloss, transparency and gives colours greater depth.

9.7 Industrial

9.7.1 Adhesives: Gum acacia is used as an adhesive for postage stamps and to make liquid glues, and although these traditional applications have largely died out, it is still used as a specialist paper adhesive. A 50% gum acacia solution is prepared, and then applied to the paper either directly from an applicator nozzle or by roller, followed by drying.

9.7.2 Ceramics: The function of gum acacia in ceramics' manufacture include: plasticiser for the moulding of delicate shapes, providing green strength prior to firing in the kiln, and as an adhesive for the application of cup and bowl handles prior to firing.

9.7.3 Pumpable and Fluid Cement Mixes: In liquid cement mixes, gum acacia is used as a suspension and plasticiser agent.

9.7.4 Fireworks/Pyrotechnics: Gum acacia is mixed with fireclay to seal the base of the containment tube of fireworks.

9.7.5 Miscellaneous: Gum acacia has been used to inhibit metal corrosion in batteries. It is also used in gunpowder mixture/cartridge powders, flotation in phosphate mining/refinement, insecticide sprays and as a detergent for removing oil.

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This book is the proceedings of the World Conference on "New developments in Acacia Gums Research and Products" held in September 2010. Dealing with the latest information on polysaccharide gum research,particularly focussed on gum Arabic, this book covers the production, identification, classification and application of these important carbohydrate polymers. Written by the world's leading experts, bringing together all the latest information in the field, it will be an essential reference for researchers in industry and academia interested in the continued advances in this area.

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